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An Australian raspy cricket established in New Zealand, *Pterapotrechus salomonoides* (Orthoptera, Gryllacrididae), with notes on ecology and first description of the male

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Abstract

The Australian genus *Pterapotrechus* Karny, 1937 (Orthoptera, Gryllacrididae) currently includes three species: *Pterapotrechus beta* (Griffini, 1909) and *P. longicornis* (Tepper, 1892) from Australia's Northern Territory, and *P. salomonoides* (Karny, 1929) from Southern Queensland. All three species were described from one adult female only, with the male being unknown in each case. None of the three species has been revised since their original descriptions. When a winged raspy cricket was first detected in New Zealand in 1990, it was attributed to the genus *Pterapotrechus* as an undescribed species. In this paper, the species *P. salomonoides* is identified based on the original description and on the examination of the holotype. The species is redescribed in detail, and the male is described for the first time. Comparison of morphology and DNA from fresh specimens collected at the type locality confirm that *P. salomonoides* is the species established in New Zealand. The expansion of the species' geographic range in New Zealand, aspects of its ecology, and possible impact on native ecosystems are discussed. *Pterapotrechus beta* is synonymized with *P. longicornis* after comparison of the holotypes.

Keywords

Australia, invasive species, Queensland, taxonomy

Introduction

Raspy crickets (Orthoptera: Gryllacrididae) are absent from New Zealand's native fauna (Trewick et al. 2022). When a 'winged wētā' was first detected in New Zealand in 1990, it was attributed to the genus *Pterapotrechus* Karny, 1937, as an undescribed species (Green and Ramsay 2003). More than three decades later, the species appears to be well established in northern New Zealand, with a steadily growing population and expanding geographic distribution, yet the insect still does not have a name.

The Australian genus *Pterapotrechus* was designated by Karny in 1937 and included three species, which had been previously placed in *Gryllacris* Serville, 1831 and in *Paragryllacris* Brunner von Wattenwyl, 1888. These are *Pterapotrechus beta* (Griffini, 1909) and *P. longicornis* (Tepper, 1892) from Australia's Northern Territory, and *P. salomonoides* (Karny, 1929) from Southern Queensland. All three species were described from one adult female only, with the male being unknown in each case. None of the three species have been revised since their original descriptions. Furthermore, the genus *Pterapotrechus* was omitted from Rentz and John's (1990) comprehensive monograph on Australian Gryllacrididae. As a result, raspy crickets in the genus *Pterapotrechus* are poorly known and difficult to identify, even for professional entomologists. The description of *Pterapotrechus salomonoides* in particular is only available in print in the German language; its absence from the web makes it inaccessible to most.

In this study, I compared female *Pterapotrechus* from northern New Zealand with the holotypes and species descriptions of each described species in the genus. I collected fresh material at the type locality of *P. salomonoides* in Tamborine Mountain, Queensland, Australia, and compared its morphology, male terminalia, and DNA with New Zealand specimens. I wrote a new description of the species, including a description of the male for the first time. I conducted a qualitative study of the insect's diet on captive specimens and analyzed the species' population growth and range expansion in northern New Zealand.

Material and methods

Collecting and morphological methods.—Adult *Pterapotrechus* specimens were collected in northern New Zealand and in Queensland, Australia, in early summer (November to January) 2021 to 2023, spotlighting in foliage in forest habitat at night and using an insect net to capture the insects. Adults were distinguished from immature individuals by their fully formed wings.

Nineteen specimens were catalogued, examined under a stereo microscope (Leica M205C with 1.0× planapochromatic objective), and measured with digital calipers. Basic statistics of all linear measurements and count data were calculated using JASP v0.18.1.0

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(RRID:SCR_015823; JASP Team 2023). Detailed photographs of morphology were taken with a Leica Flexacam C3 camera mounted on a Leica M205C microscope or using a DSLR camera (Nikon Z7II) with Raynox DCR-250 conversion lens on Micro-Nikkor AF 105 mm 1:2.8 objective and Nikon PB-6 bellows, mounted on a Cognisys Stackshot 3× automated rail. Focus stacks were generated using the software Helicon Focus 8.2.2 Pro (RRID:SCR_014462).

All specimens are held in the Phoenix Lab collection at Massey University, Palmerston North, New Zealand (MPN), except for one adult male, which was deposited at the Queensland Museum in Brisbane, Australia (QM).

Institutional abbreviations.—

GNU	Guangxi Normal University, China
iNaturalist	Available from iNaturalist.org [accessed 2 July 2024]
MPN	Phoenix Lab, Massey University, Palmerston North, New Zealand
NRM	Swedish Museum of Natural History, Stockholm, Sweden
OUM	Oxford Museum of Natural History, UK
QM	Queensland Museum, Brisbane, QLD, Australia
SAMA	South Australia Museum, Adelaide, SA, Australia

The two-letter codes in the Material examined section refer to the New Zealand entomological regions (Crosby et al. 1998) (Fig. 11 and Suppl. material 1: fig. S4).

Molecular analysis.—To test whether *Pterapotrechus* collected in New Zealand and in Queensland, Australia, belong to the same species, genomic DNA was extracted from the leg tissue of six specimens using a one-step Chelex double-stranded DNA extraction protocol modified from Casquet et al. (2011). Leg tissue was submerged in 300 µl 5% Chelex-100 (BioRad) and 40 µg Proteinase K. After overnight incubation, samples were heated to 90 °C for 10 minutes then centrifuged at 20,000 g for 10 minutes. The cytochrome c oxidase I (COI) gene of the mitochondrial genome was amplified using polymerase chain reaction (PCR) on a single fragment spanning 1040 base pairs (bp) using the invertebrate primers LCO1490 (Folmer et al. 1994) and H7005-mod1 (Donald et al. 2005). Amplified DNAs were purified using an iNtRON MEGAquick-spin Plus Total Fragment DNA Purification Kit (iNtRON Biotechnology, Republic of Korea) and sequenced using a BigDye Terminator v3.1 Cycle Sequencing Kit on an ABI 3730xl DNA Analyser (Applied Biosystems Inc., Carlsbad, CA).

Six sequences were submitted to GenBank (Benson et al. 2013); accession numbers (PP971675–PP971680) are listed in the Material examined section. The sequence for one additional *Ultragryllacris rubricapitis* Bin & Bian, 2021 was used as an outgroup (GenBank OM683271). Detailed information on the origin of each specimen included in the analysis can be found in the Suppl. material 1: tables S1, S2.

Nucleotide sequences were edited using Sequencher 5.1 (Gene Codes Corporation, Ann Arbor, MI, USA) and aligned in ClustalX 2.1 (Thompson et al. 1997, Larkin et al. 2007). Phylogenetic relationships were inferred by using the Maximum Likelihood method and Tamura-Nei model (Tamura and Nei 1993) in MEGA11 (Tamura et al. 2021). Initial tree(s) for the heuristic search were obtained automatically by applying the maximum parsimony method.

Population growth and geographic expansion in northern New Zealand.—*Pterapotrechus* observations in New Zealand were extracted from iNaturalist for a 12-year period starting 1 July 2012 and ending 30 June 2024.

To obtain an estimate of population growth, only observations from the city of Auckland were considered, as a percentage of the total number of insect observations recorded on iNaturalist in Auckland over the time period. The polygon delimiting the city of Auckland in iNaturalist is mapped in the Suppl. material 1: fig. S6. Since *Pterapotrechus* had already established in Auckland in 2012, the observed changes in the number of observations per year are not confounded by the species expanding its geographic range.

To visualize the species' geographic expansion, all New Zealand observations of *Pterapotrechus* were mapped in QGIS 3.38.0 (QGIS.org 2024; RRID:SCR_018507). Observations with obscured or private geographic coordinates were discarded unless a precise location could be obtained from the observer.

Keeping specimens in captivity.—Live insects were housed indoors at a temperature of 22 °C in 45 × 45 × 80 cm reptile enclosures made of aluminum alloy mesh (Suppl. material 1: fig. S5). The bottom of each cage was filled with a 5 cm thick layer of mulch and leaf litter. Three potted plants — a five finger *Pseudopanax arboreus* (L.f.) Allan, a broadleaf *Griselinia littoralis* Raoul, and an akeake *Dodonaea viscosa* Jacq. — were kept in each cage to create a miniature New Zealand native forest ecosystem.

Up to three *Pterapotrechus* specimens were housed in each cage, which they shared with a variety of other live forest invertebrates, including tree wētā *Hemideina thoracica* (White, 1846), katydids *Caedicia simplex* (Walker, 1869), rhaphidophorids (*Neonetus* sp. and *Pachyrhamma* sp.), moths (Families Noctuidae and Geometridae), crane flies (*Leptotarsus* sp.), blowflies (*Calliphora* sp.), and garden soldier flies *Exaireta spinigera* (Wiedemann, 1830). Supplemental feeding was provided in the form of grated apple, grated carrot, pet food (mixed meat and fish pâté), and occasionally dead invertebrates, all served in petri dishes placed at the bottom of the cage. Water was added only to the plant pots.

Results

Identification of Pterapotrechus in New Zealand.—The holotypes of all species in the genus *Pterapotrechus* Karny, 1937 are pictured in Figs 1–3. *Pterapotrechus salomonoides* (Karny, 1929) immediately stands out as the possible identity for the species that has established in New Zealand in light of the bilobed subgenital plate (Figs 3B, 9E) and the short, heavily recurved ovipositor (Figs 3D, 9F). These features are in contrast to the trapezoidal subgenital plate with a double keel (Figs 1B, 2D) and the long, relatively straight ovipositor (Figs 1D, 2A) in the remaining two species of *Pterapotrechus*. Measurements of specimens collected in New Zealand and southern Queensland, Australia, are also in agreement with the *P. salomonoides* holotype (Fig. 4).

The male terminalia of the specimens collected in New Zealand and at the type locality of *P. salomonoides* in Tamborine Mountain, QLD, Australia, are identical. Moreover, mtDNA COI sequences from New Zealand specimens fit within the variation of *P. salomonoides* from Tamborine Mountain and the surrounding area (Fig. 5B). This information indicates that the insect that has established in New Zealand is *Pterapotrechus salomonoides* (Karny, 1929).

The two other species in the genus *Pterapotrechus* originate from the coastal regions of Australia's Northern Territory. The holotype of *P. beta* (Griffini, 1909) was collected in Port Essington on the northern coastline, whereas the type locality of *P. longicornis* (Tepper, 1892) is Palmerston City near Darwin. The type specimens of these two species have similar measurements (Fig. 4), identical subgenital plates (Figs 1B, 2D), and cannot be differentiated from

one another based on any morphological features. I suggest that *Pterapotrechus longicornis* and *P. beta* are the same species, with the latter being a junior synonym of the former.

Taxonomy

Order Orthoptera Latreille, 1793
Suborder Ensifera Chopard, 1921
Infraorder Tettigoniidea Kevan, 1982
Superfamily Stenopelmatoidea Burmeister, 1838
Family Gryllacrididae Blanchard, 1845
Subfamily Hyperbaeninae Cadena-Castañeda, 2019
Tribe Paragryllacridini Cadena-Castañeda, 2019

Genus *Pterapotrechus* Karny, 1937

Pterapotrechus Karny, 1937: 73.
Pterapotrechus — Green and Ramsay 2003: 75–77.
— Cadena-Castañeda 2019: 99.

Diagnosis.—(After Karny 1937) The main feature differentiating *Pterapotrechus* from most other Australian genera of Gryllacrididae is the prominent angular ridge running from the insertion of the antennae to the base of the mandibles and delimiting the frons on the sides. While this feature is shared with the genus *Apotrechus* Brunner von Wattenwyl, 1888, the latter genus is wingless. In *Pterapotrechus*, fore- and hindwings are well developed in adults of both sexes.

Habitat and ecology.—*Pterapotrechus* are nocturnal, predatory rainforest insects.

Distribution.—Native to coastal Northern Territory and Queensland, Australia, and extending into northern New South Wales. Introduced in North Island, New Zealand.

Etymology.—From the Ancient Greek πτερόν (pterón), 'wing', (Karny 1937) and ἀποτρέχω (apotrechus), 'avoidant, running away' (Brunner von Wattenwyl 1888). A winged version of the wingless genus *Apotrechus* Brunner von Wattenwyl, 1888. *Pterapotrechus* is male gender.

Type species.—*Paragryllacris beta* Griffini, 1909.

Pterapotrechus longicornis (Tepper, 1892)

Figs 1, 2, 4

Gryllacris longicornis Tepper, 1892: 146.
Paragryllacris beta Griffini, 1909: 329 **syn. nov.**
Gryllacris longicornis — Kirby 1906: 147.
Paragryllacris longicornis — Karny 1928: 214.
Pterapotrechus longicornis — Karny 1937: 73. — Cadena-Castañeda 2019: 99.
Paragryllacris beta — Karny 1928: 206.
Pterapotrechus beta — Karny 1937: 73. — Cadena-Castañeda 2019: 99.

Diagnosis.—This is the larger of the two species in the genus *Pterapotrechus* (Fig. 4). Body longer than 30 mm. Tegmina longer than 40 mm, clearly projecting beyond the abdomen. Ovipositor long (> 25 mm) and only weakly recurved upwards (Figs 1D, 2A). Frons entirely pale (Figs 1C, 2B). Female subgenital plate trapezoidal, with two keels converging at the base (Figs 1B, 2D). Male unknown.

Habitat and distribution.—Rainforests in Australia's Northern Territory.

Etymology.—From the Latin *longus* (adj.), 'long', and *cornum* (noun), 'horn', after the insect's very long antennae "exceeding four times the length of the body" (Tepper 1892). '*Longicornis*' is an adjective of the third declension.

Material examined.—(See also Suppl. material 1: table S2) **Holotype:** AUSTRALIA • ♀; Northern Territory, Palmerston; 12.5°S, 131.0°E; 10 m.a.s.l.; 3 Aug. 1886; S.J. Magarey leg.; SAMA 14-1093.

Other material. AUSTRALIA • 1 ♀; Northern Territory, Port Essington; 11.3°S, 132.2°E; 0 m.a.s.l.; OUM ORTH1002 (Holotype of *Paragryllacris beta* Griffini, 1909).

Description.—Refer to the original description in Tepper 1892. See also Figs 1, 2 in this work.

Pterapotrechus salomonoides (Karny, 1929)

Figs 3–13

Paragryllacris salomonoides Karny, 1929: 14.
Pterapotrechus salomonoides — Karny 1937: 73.
— Cadena-Castañeda 2019: 99.

Diagnosis.—*P. salomonoides* is the smaller of the two species in the genus *Pterapotrechus* (Fig. 4). Body usually shorter than 30 mm. Tegmina always shorter than 30 mm. Ovipositor short (< 20 mm) and strongly recurved upwards (Fig. 9F). Frons black (Fig. 6B). Female subgenital plate bilobed (Fig. 9E). Male subgenital plate triangular, bearing numerous dense, stout spinules on the median keel underneath (Fig. 9B, C).

Habitat and distribution.—Coastal forests in southern Queensland and northern New South Wales, Australia. Introduced by anthropogenic means and naturalized in North Island, New Zealand.

Etymology.—Named for its resemblance to katydids in the genus *Salomona* Blanchard, 1853 (Karny 1929). '*Salomonoides*' is an adjective of the third declension.

Material examined.—(See also Suppl. material 1: table S1) **Holotype:** AUSTRALIA • ♀; Queensland, Tamborine Mountain; 27.9°S, 153.2°E; 500 m.a.s.l.; 1910–1913; E. Mjöberg leg.; NRM ORTH 0000231.

Representative male: AUSTRALIA • 1 ♂; Queensland, Tamborine Mountain, MacDonald Rainforest Circuit; 27.91845°S, 153.20455°E; 500 m.a.s.l.; 15 Nov. 2023; D. Hegg leg.; rainforest, in foliage; insect net; QM T260852.

Other material. AUSTRALIA – Queensland (QLD) • 1♀; Tamborine Mountain, MacDonald Rainforest Circuit; 27.91845°S, 153.20455°E; 500 m.a.s.l.; 15 Nov. 2023; D. Hegg leg.; rainforest, in foliage; insect net; GenBank: PP971680; MPN OR0548 • 1♀; Tamborine Mountain, Esme Lahey Environmental Park; 27.94776°S, 153.19386°E; 530 m.a.s.l.; 13 Nov. 2023; D. Hegg leg.; rainforest, in foliage; insect net; GenBank: PP971677; MPN OR0546 • 1♂; same collection data as for preceding; MPN OR0547 • 1♂; Springbrook NP, Purling Brook Falls; 28.18950°S, 153.27177°E; 600 m.a.s.l.; 18 Nov. 2023; D. Hegg leg.; in park map display case; insect net; GenBank: PP971678; MPN OR0543 • 1♂; same collection data as for preceding; MPN OR0549 • 1♀; Binna Burra; 28.19925°S, 153.18819°E; 820 m.a.s.l.; 14 Nov. 2023; Rainforest, D. Hegg leg.; rainforest, in foliage; insect net;

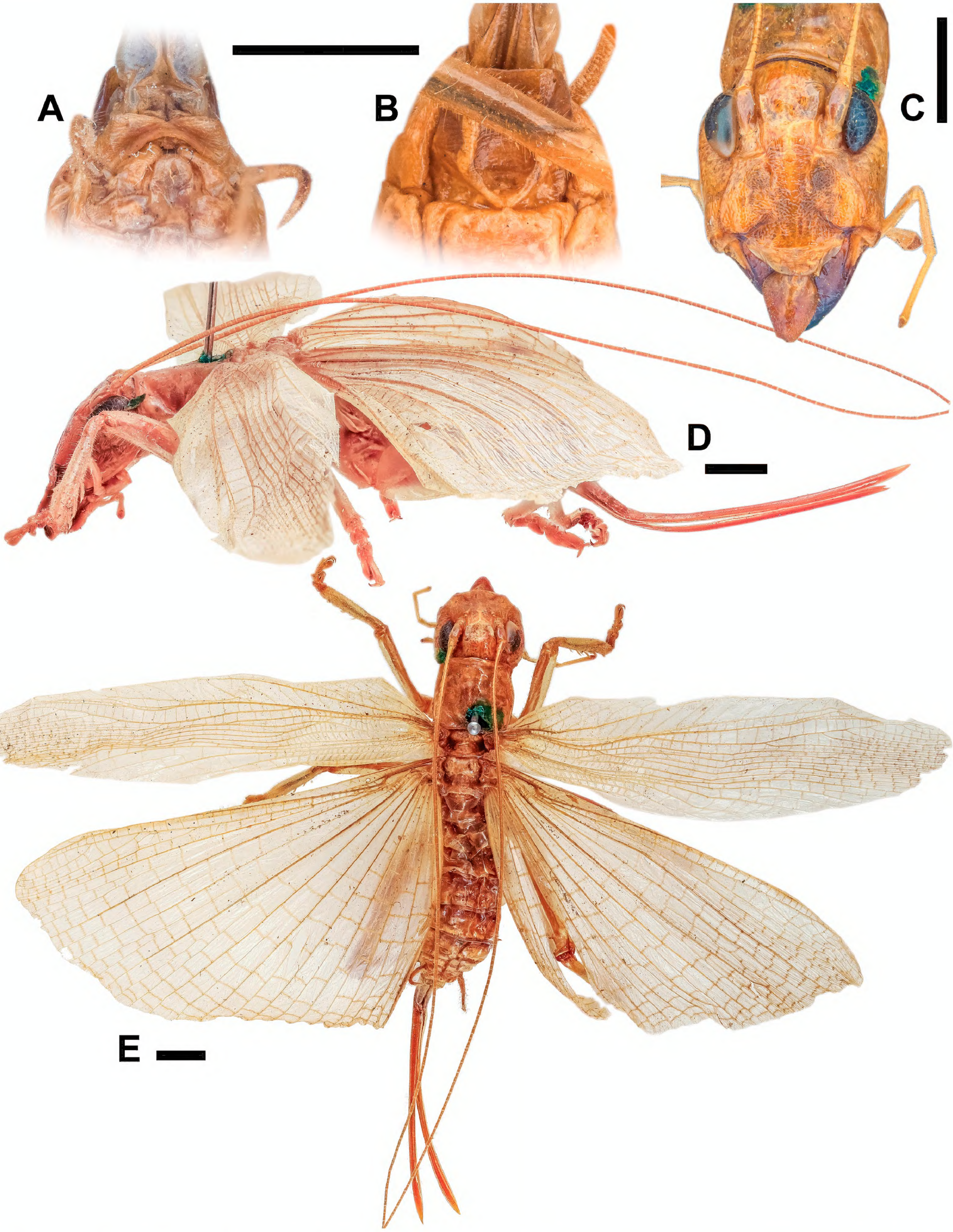


Fig. 1. *Pterapotrechus longicornis* (Tepper, 1892) holotype. Adult ♀. Palmerston, Northern Territory, Australia. SAMA 14-1093. **A.** Suranal plate. **B.** Subgenital plate. **C.** Frontal view of head. **D.** Lateral view of insect. **E.** Dorsal view of insect. Scale bars: 5 mm. All photographs courtesy of Dr. Ben Parslow, collection manager for terrestrial invertebrates at the South Australian Museum, Adelaide, AUS.

GenBank: PP971679; MPN OR0544 • 1♂; same collection data as for preceding; MPN OR0545. **NEW ZEALAND** – Auckland (AK) • Helensville, Mangakura Road; 36.69°S, 174.45°E; 20 m.a.s.l.; 13 Jan. 2021; N. Clayton leg.; inside house; jar; MPN OR0440 • 4♂♂, 1♀; Tahuna Torea Reserve; 36.87169°S, 174.88205°E; 0 m.a.s.l.; 23 Nov. 2023; D. Hegg leg.; native forest, in foliage; insect net; MPN OR0535 to OR0538, OR0533 • 1♀; same collection data as for preceding; GenBank: PP971675; MPN OR0544. – Northland (ND) • 1♂; Kerikeri; 35.21570°S, 173.96044°E; 20 m.a.s.l.; 21 Nov. 2021; D. Hegg leg.; native forest, in foliage; insect net; MPN OR0541 • 1♂; Kerikeri; 35.21797°S, 173.95276°E; 20 m.a.s.l.; 29 Nov. 2021; D. Hegg leg.; native forest, in foliage; insect net; MPN OR0539 • 1♀; Kerikeri; 35.21649°S, 173.96051°E; 20 m.a.s.l.; 13 Dec. 2022; native forest, in foliage; insect net; MPN OR0540 • 1♀; same collection data as for preceding; GenBank: PP971676; MPN OR0542.

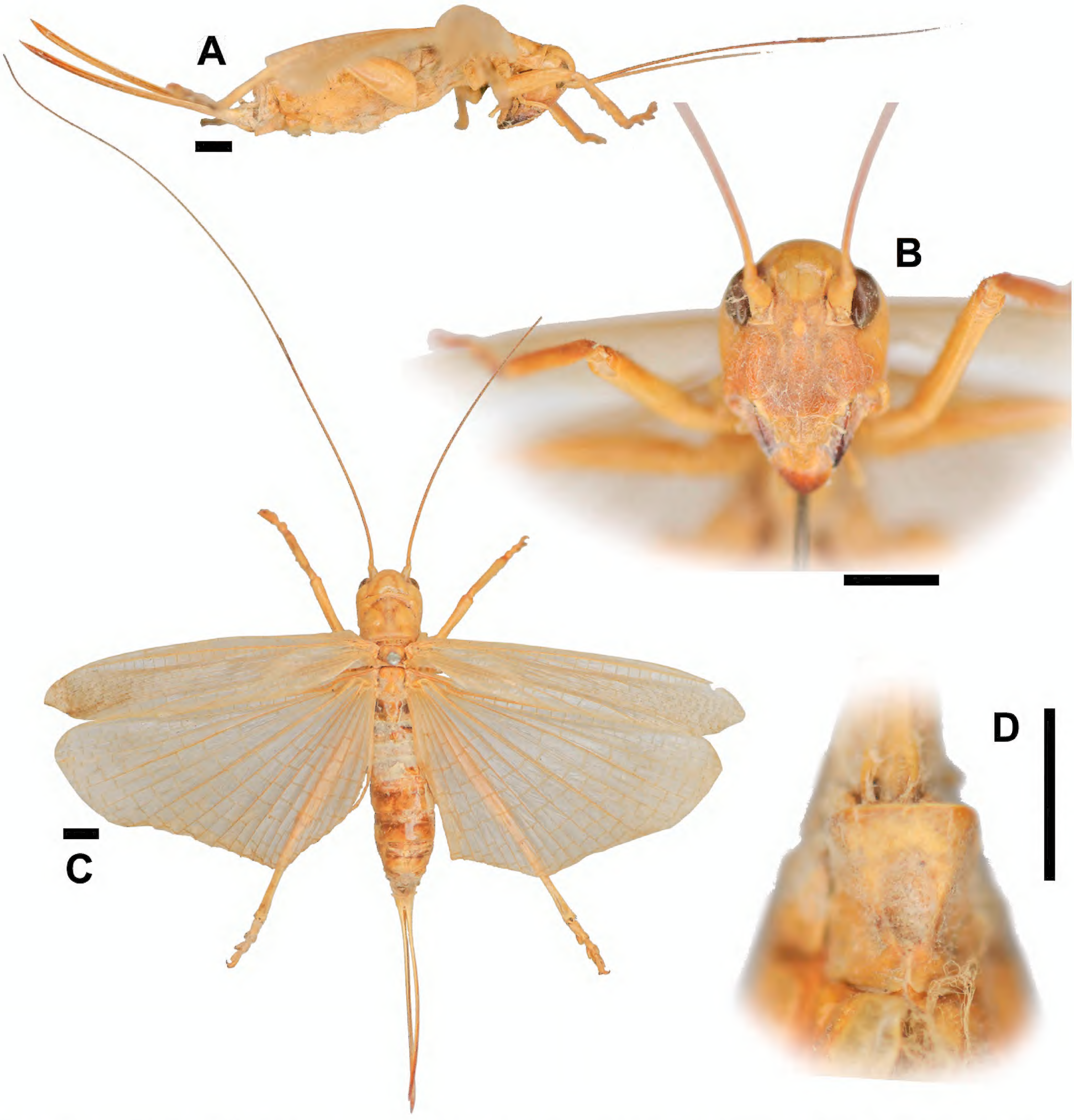


Fig. 2. *Pterapotrechus beta* (Griffini, 1909) holotype. Adult ♀. Port Essington, Northern Territory, Australia. OUM ORTH1002. **A.** Lateral view of insect. **B.** Frontal view of head. **C.** Dorsal view of insect. **D.** Subgenital plate. Scale bars: 5 mm. All photographs courtesy of Mr. Robert Douglas, collections assistant at the Oxford Museum of Natural History, UK.

Description.—Karny's (1929) original description of the species (see Suppl. material 1: appendix A) is for the adult female only. The male was never described. While Karny's description is minutiously accurate, it is wordy and hard to follow with few illustrations. Curiously, it lacks any mention of the stridulatory apparatus, which in Gryllacrididae is present in both males and females.

A new description of the species is given here, based on the examination of 19 fresh specimens, and including a description of the male for the first time.

Measurements. See Table 1. Females tend to be slightly larger than males, but not significantly so.

Head. (Fig. 6A, B). No noticeable sexual dimorphism. Vertex heavily domed, glabrous, smooth, and shiny, pale. Median ocellum visible as a white dot. Just below the ocellum, a shallow V-shaped line separates the pale fastigium from the black frons. The latter is wrinkled throughout and is delimited on the sides by prominent ridges running from the insertions of the antennae to the base of the mandible; these ridges are diagnostic of the genus *Pterapotrechus*. Mandibles very strong, sharp. Labrum and mandibles dark red/brown. Labial and maxillary palpi pale. Antennae uniform brown, very long, four times the body length or more.

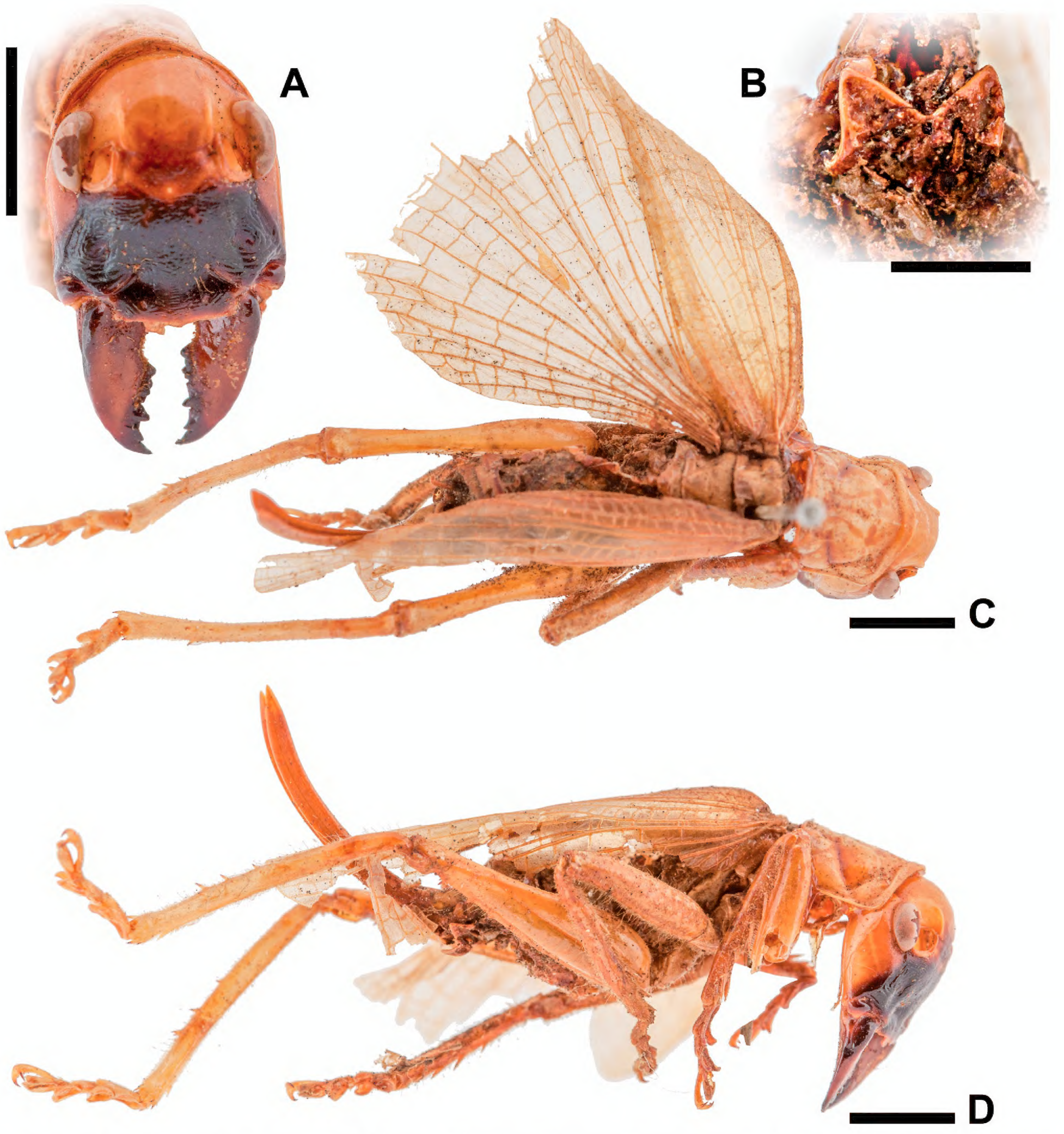


Fig. 3. *Pterapotrechus salomonoides* (Karny, 1929) holotype. Adult ♀. Tamborine Mountain, Queensland, Australia. NRM ORTH 0000231. **A.** Frontal view of head. **B.** Subgenital plate. **C.** Dorsal view of insect. **D.** Lateral view of insect. Scale bars: 2 mm (**B**); 5 mm (**A, C, D**). All photographs courtesy of Mr. Niklas Apelqvist of the Swedish Museum of Natural History, Stockholm, SE.

Table 1. Measurements and spine counts of *Pterapotrechus salomonoides* (Karny, 1929). Median values are shown, followed by minimum and maximum in brackets.

Measurement	*Males*	*Females*
Sample size	10	9
Body length (mm)	25.9 (23.8–28.1)	27.6 (21.0–30.7)
Pronotum length (mm)	5.3 (4.8–6.8)	6.2 (4.8–6.9)
Pronotum width (mm)	6.2 (4.8–7.1)	6.3 (4.9–7.3)
Ovipositor length (mm)		15.4 (13.6–16.8)
Ratio ovipositor to body length		0.59 (0.50–0.70)
Length of male cerci (mm)	4.0 (2.6–5.9)	
Length of fore femur (mm)	8.1 (7.5–9.2)	8.0 (7.2–9.5)
Length of mid femur (mm)	8.4 (7.4–9.2)	8.3 (7.6–9.8)
Length of hind femur (mm)	12.9 (11.0–14.5)	13.2 (11.0–15.2)
Length of hind tibia (mm)	12.8 (12.3–13.6)	13.3 (10.7–14.4)
Ratio hind tibia to body length	0.51 (0.44–0.53)	0.47 (0.43–0.62)
Forewing length (mm)	24.2 (20.5–26.7)	21.8 (19.5–26.8)
Hindwing length (mm)	25.6 (21.5–27.9)	22.0 (18.9–28.7)
Ratio hindwing to forewing length	1.06 (0.96–1.11)	1.07 (0.96–1.09)
Stridulatory pegs anterior row T2	5 (3–6)	4 (3–8)
Stridulatory pegs posterior row T2	8 (6–12)	7 (5–10)
Stridulatory pegs anterior row T3	8 (5–10)	8 (7–10)
Stridulatory pegs posterior row T3	8 (6–10)	9 (8–11)
Hind femur ventral spines, inner edge	1 (0–1)	1 (0–1)
Hind femur ventral spines, outer edge	2 (2–4)	2 (2–4)
Hind tibia dorsal spines, inner edge	3 (2–4)	3 (2–3)
Hind tibia dorsal spines, outer edge	2 (2–4)	2 (2–4)

Thorax. Pronotum pale; reddish-brown only near the margins. Anterior margin convex in the middle; posterior margin straight. Anterior corners of the lateral lobes in the shape of sharp right angles; posterior corners truncated. A straight median sulcus and two curved sulci on either side of the pronotal discus give the pronotum a characteristic dorsal pattern (Fig. 6D). Dark markings on parts of the sulci are often present but not in all individuals.

Wings. (Fig. 7). Fore- and hindwings well developed in adult males and females. Forewings truncated in apical half, shaped like the blade of a kayak paddle; shorter than body, yet always reaching beyond the end of the abdomen; falling well short of the apex of the ovipositor in females (Fig. 10B). Hindwings on average 6% longer than the forewings. Wing shape as in *Chauliogryllacris acaropenates* Rentz et al., 2018 and in Béthoux 2012: Fig. 16. Wing venation simpler than in most other Australian Gryllacrididae (Béthoux 2012), with veins CuA, CuPaα, and CuPaβ fused into a single vein in both forewing and hindwing. Veins MA and MP share the basal stem with RP in the hindwings.

Legs. Fore and mid femora approximately one-third of body length, unarmed. Fore and mid tibiae hairy above; armed ventrally with one pair of spines at the apex (Fig. 6F) and with four pairs of strong, sharp spurs that are articulated at the base (Fig. 6F; detail in Fig. 6C). Hind femora smooth inside, but with a scabrous stridulatory file near the dorsal edge in basal third (Fig. 8C, D); armed ventrally in distal half often but not always with one spine on inner edge, always with two to four spines on outer edge. Hind tibiae hairy above, unarmed in basal half (Fig. 6G); armed ventrally with one pair of spines near the apex; armed dorsally on both sides with two to four spines in distal half (Fig. 6G). Hind tibiae armed with three pairs of apical spurs, one dorsal and two ventral, the ventral spurs being recurved upwards.

Abdomen. Shape typical of other Gryllacrididae, with two rows of stridulatory pegs laterally on both tergites T2 and T3 (Fig. 8A, B). Peg counts in all four rows are reported in Table 1.

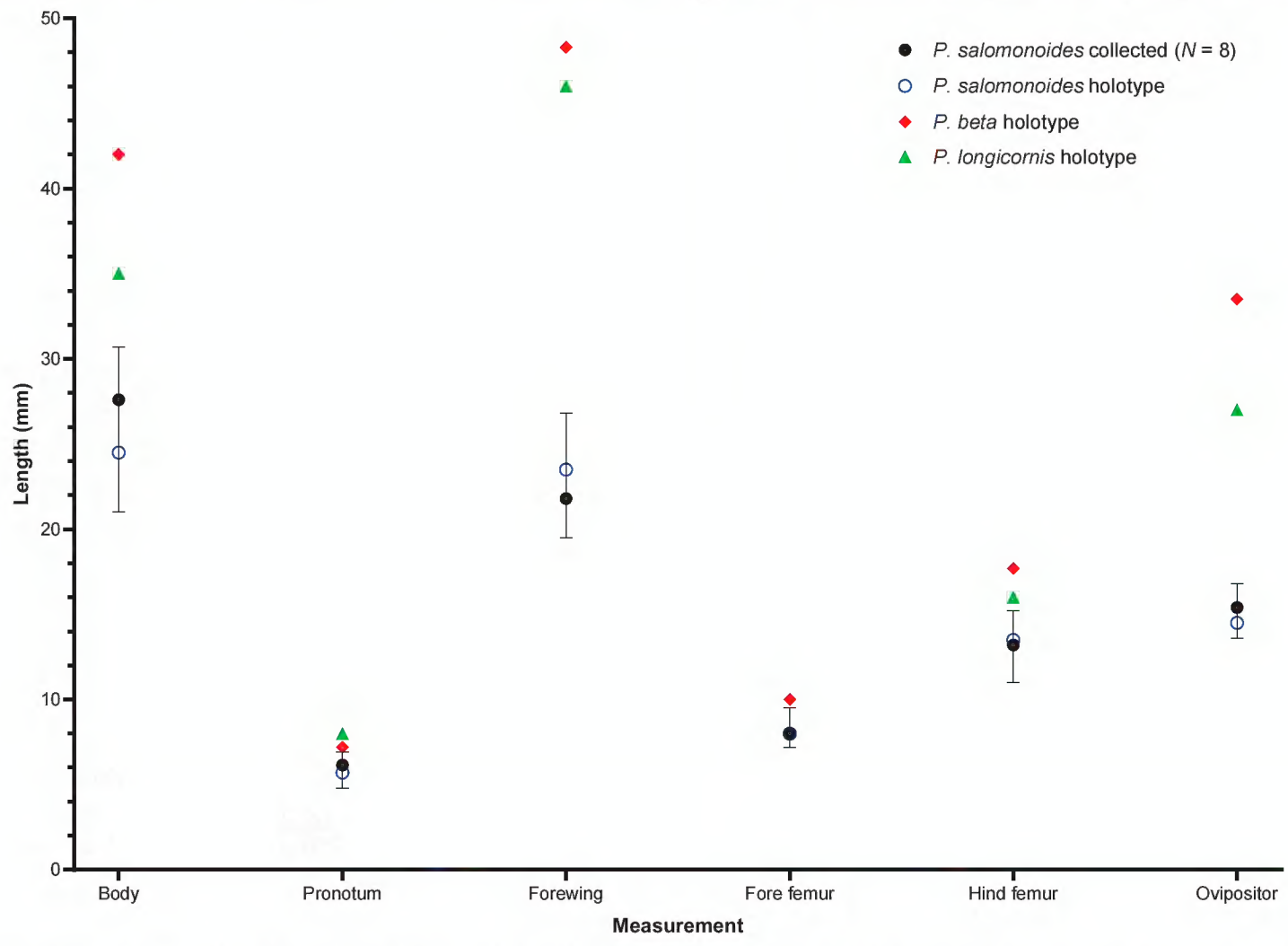
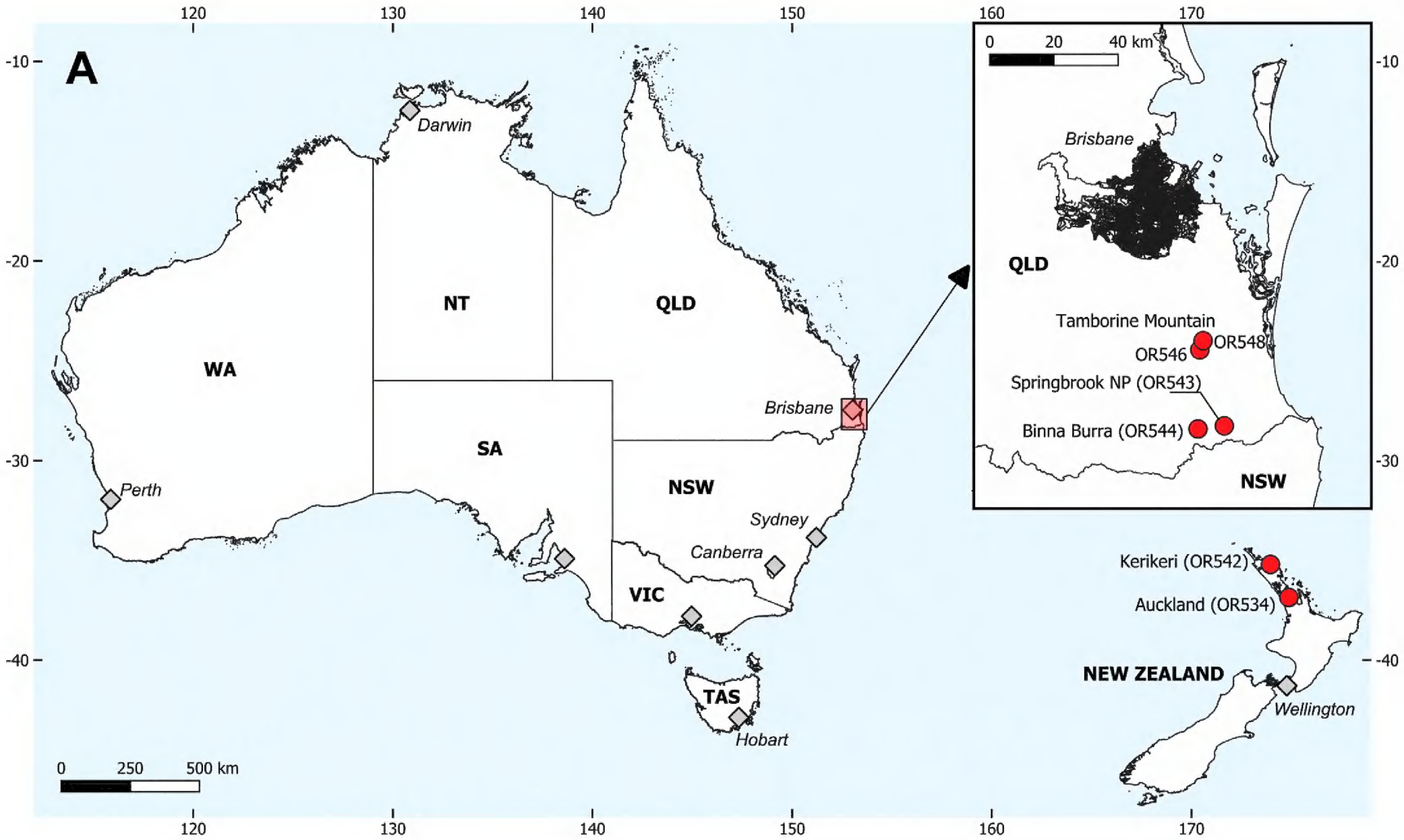


Fig. 4. Measurements of adult female *Pterapotrechus*. Full circles with error bars = *Pterapotrechus salomonoides* (Karny, 1929) specimens collected in New Zealand and Australia as part of this study (N = 8). Empty circles = *Pterapotrechus salomonoides* (Karny, 1929) holotype. Red diamonds = *Pterapotrechus beta* (Griffini, 1909) holotype. Green triangles = *Pterapotrechus longicornis* (Tepper, 1892) holotype. All type material measurements are from the species' original descriptions (Karny 1929, Griffini 1909, Tepper 1892).



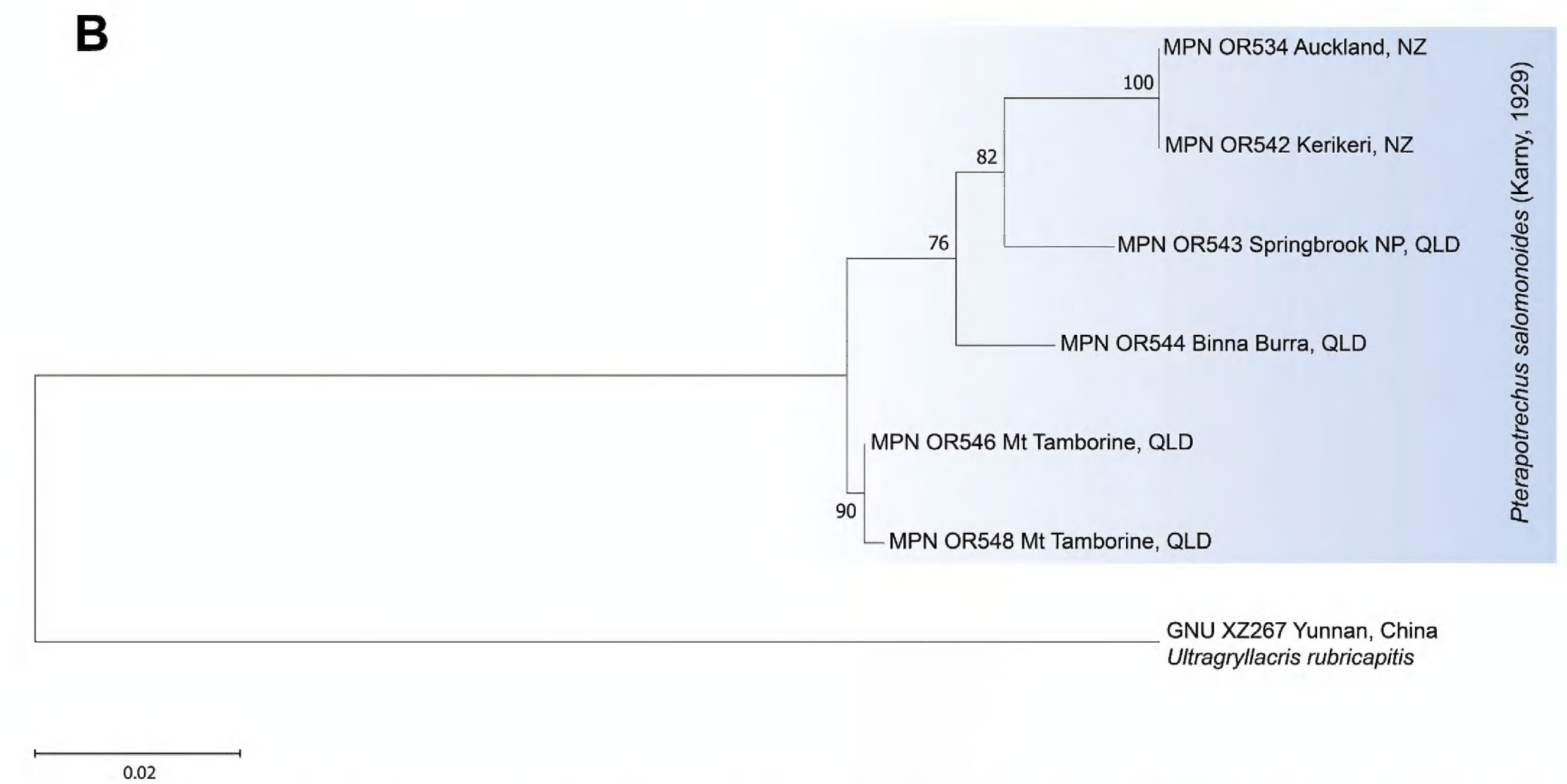


Fig. 5. Molecular analysis of *Pterapotrechus salomonoides* (Karny, 1929) specimens from New Zealand and Australia. **A.** Collection localities in New Zealand and Australia. **B.** Gene tree generated using maximum likelihood analysis of 1040 bp of mtDNA (COI) from seven specimens and 1000 bootstrap replications. The tree with the highest log likelihood (-22130.21) is shown. Numbers next to the branches indicate the percentage of trees in which the associated taxa are clustered together. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site and is rooted with the sequence for GNU XZ267 from Yunnan, China (GenBank OM683271) (Lu et al. 2023). Detailed information for each specimen included in this analysis can be found in Suppl. material 1: tables S1, S2.

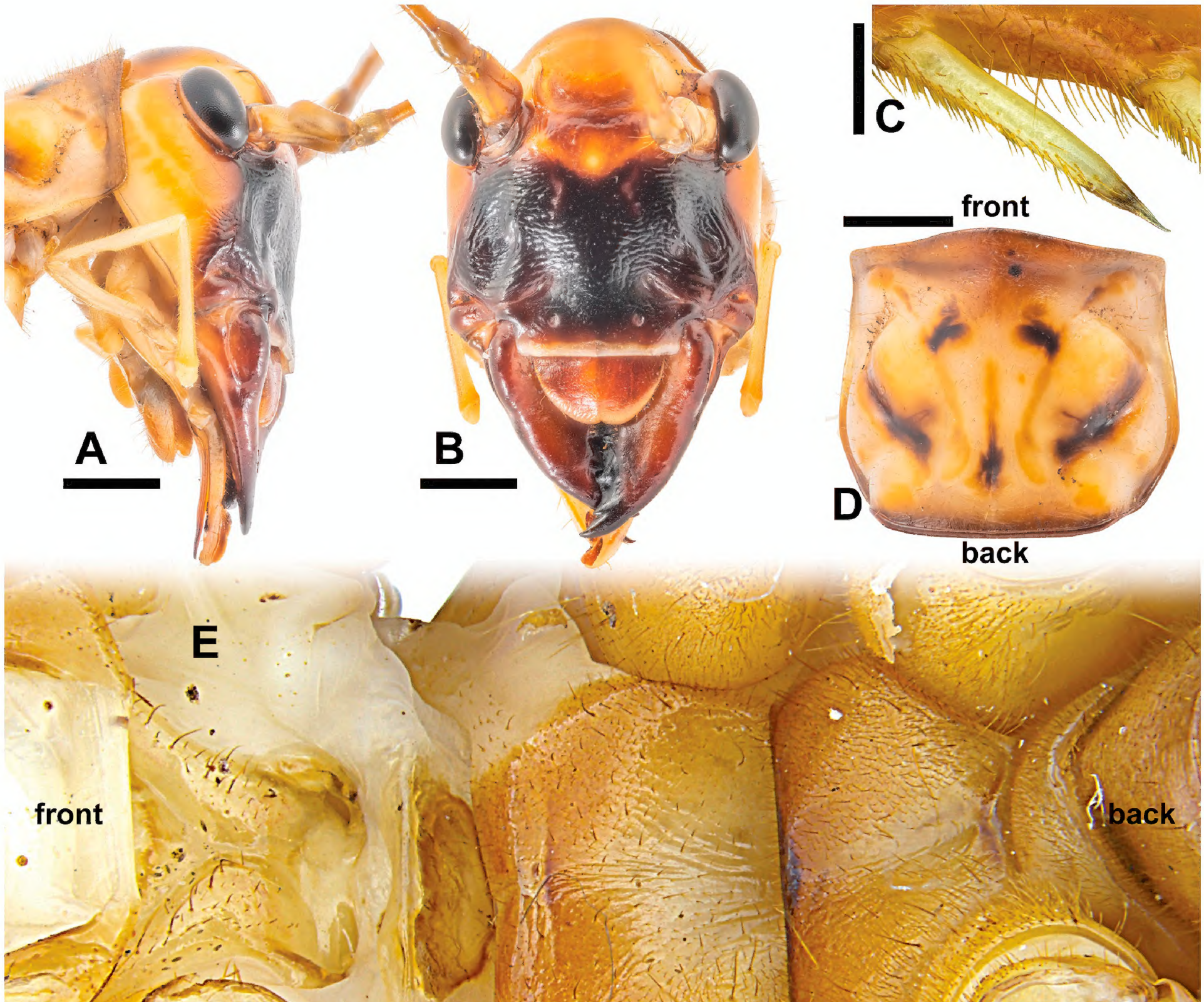


Fig. 6. *Pterapotrechus salomonoides* (Karny, 1929) general morphology. **A, B.** Head. Adult ♂. Auckland, NZ. MPN OR536. **C.** Detail of ventral spur on mid tibia. Adult ♂. Springbrook NP, QLD. MPN OR543. **D.** Pronotum, dorsal view. Adult ♂. Auckland, NZ. MPN OR536. **E.** Sternum. Adult ♀. Tamborine Mountain, QLD. MPN OR546. **F.** Mid tibia. Adult ♀. Tamborine Mountain, QLD. MPN OR548. **G.** Hind tibia. Adult ♀. Tamborine Mountain, QLD. MPN OR548. Scale bars: 500 μm (**C**); 2 mm (**A, B, D, E, F, G**).

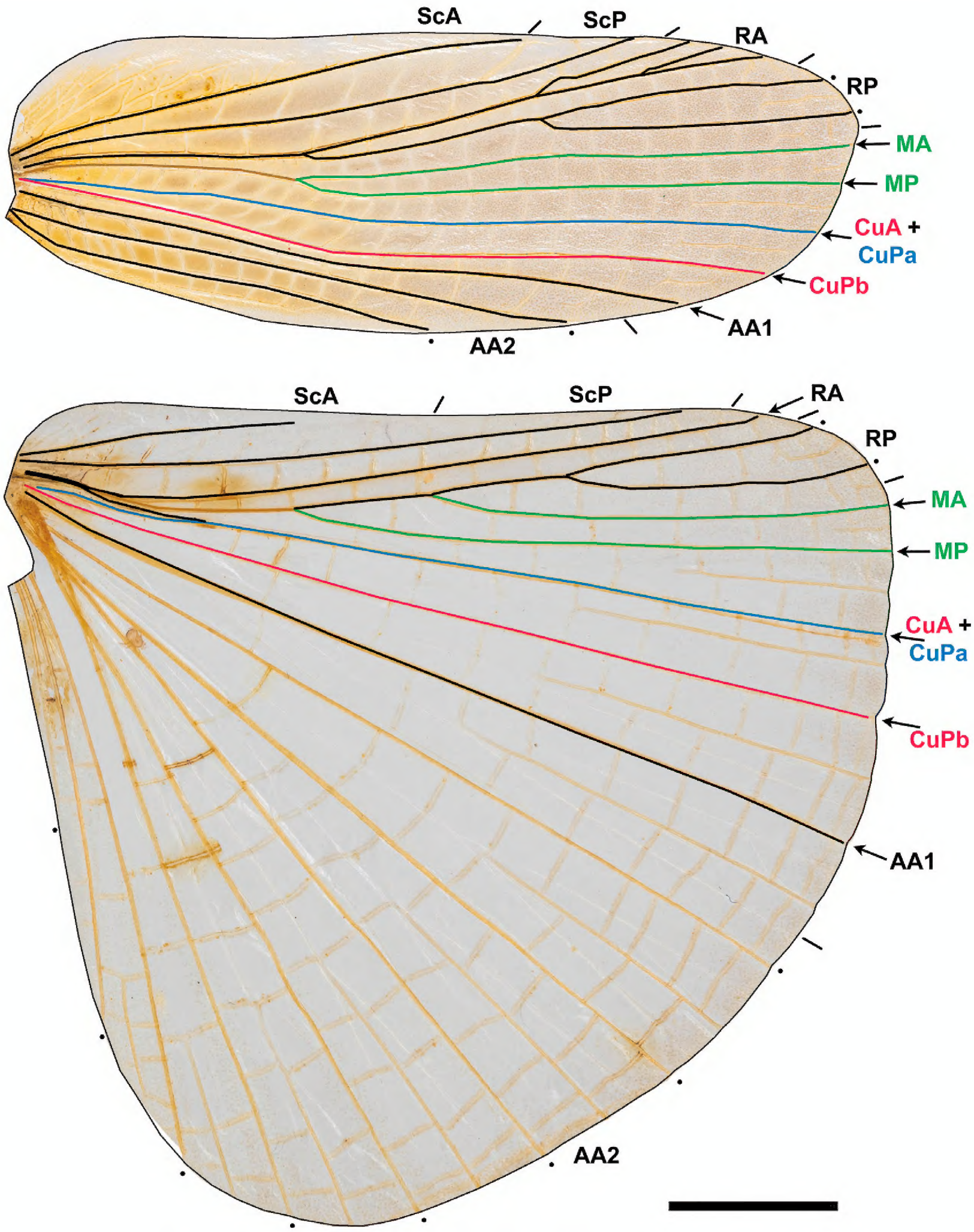


Fig. 7. *Pterapotrechus salomonoides* (Karny, 1929) wings and wing venation in adult ♂. Tamborine Mountain, QLD. MPN OR547. Labeling of wing venation follows Béthoux and Nel 2001, Béthoux 2012, Rentz et al. 2018. Scale bar: 5 mm.

Male terminalia. Internal male genitalia soft, non-sclerotized, as in most other Australian Gryllacrididae (Rentz and John 1990, Rentz et al. 2018). Suranal plate pale, roughly trapezoidal, with two very prominent, darkened, cat's ear-shaped lobes on the apical vertices (Fig. 9A). Subgenital plate triangular, bearing numerous dense, stout spinules on the median keel underneath (Fig. 9B, C).

Female terminalia. Subgenital plate glabrous, with two pointed lobes giving it the shape of a capital letter M (Fig. 9E). Ovipositor on average 60% of body length, strongly recurved upwards (Fig. 9F).

Eggs. One female from Kerikeri, New Zealand (MPN OR0540) was dissected and found to be carrying 62 eggs in various stages of development. Mature eggs are yellow, elongated, between 4 mm and 4.5 mm long and approx. 1.5 mm wide at center (Fig. 9G).

Geographic distribution in New Zealand.—As of mid-2024, the known geographic distribution of *Pterapotrechus salomonoides* (Karny, 1929) in New Zealand is centered around Auckland (36.9°S, 174.8°E) and extends northwards to Cable Bay, Northland (35.0°S, 173.5°E) and southwards to a line joining Raglan, Hamilton, and Tauranga (Latitude 37.5°S) (Fig. 11).

A total of 436 observations of *Pterapotrechus salomonoides* in New Zealand were recorded in the iNaturalist (https://www.inaturalist.org) database from 1 July 2012 to 30 June 2024. Ten of these

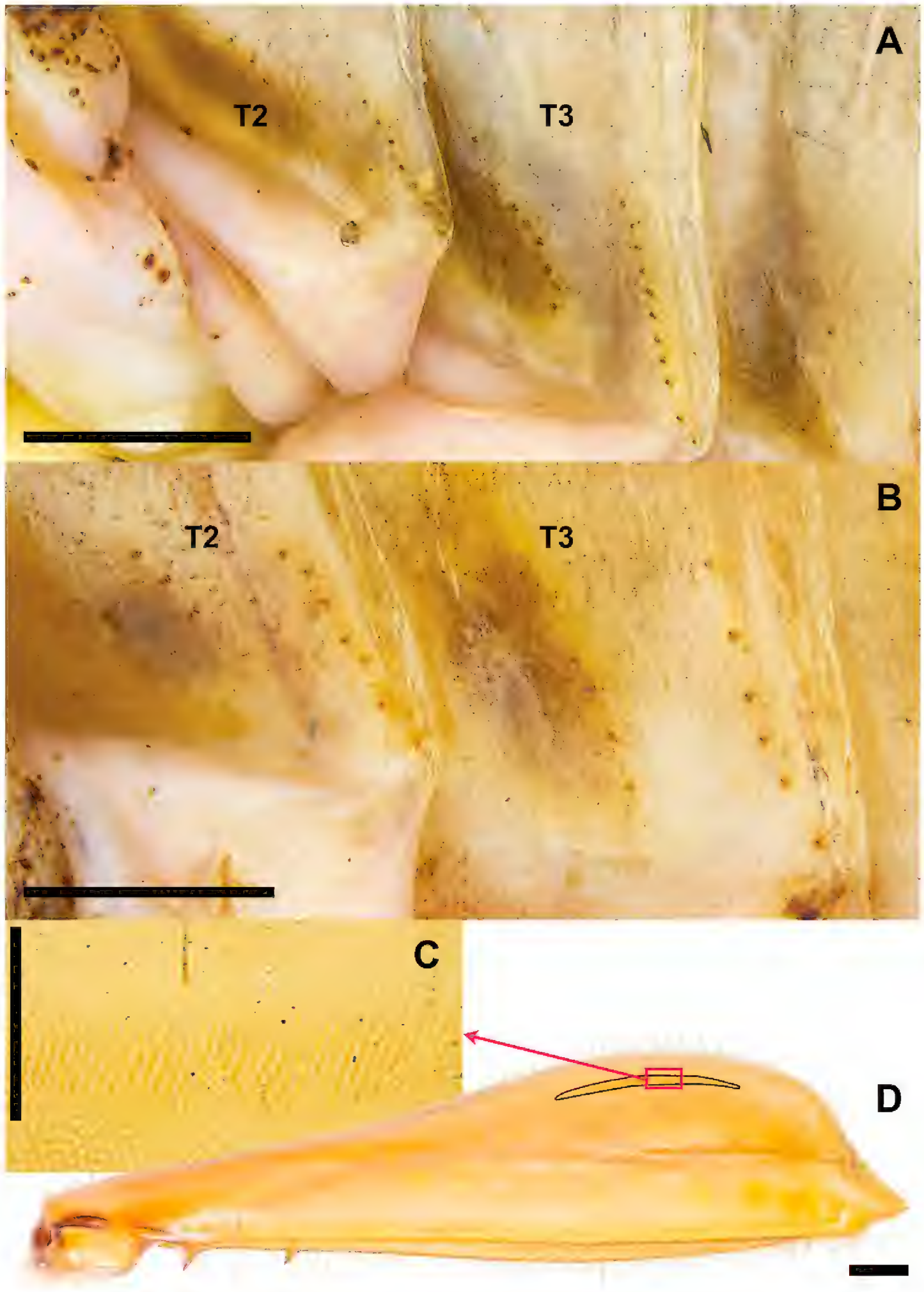


Fig. 8. *Pterapotrechus salomonoides* (Karny, 1929) stridulatory apparatus. Tamborine Mountain, QLD. **A, B.** Stridulatory pegs on the second (T2) and third (T3) abdominal tergites. **A.** Adult ♂. MPN OR547. **B.** Adult ♀. MPN OR546. **C, D.** Stridulatory file on inner surface of hind femur. Adult ♀. MPN OR548. Scale bars: 250 μm (**C**); 1 mm (**A, B, D**).

observations were discarded for having obscured or private coordinates that could not be obtained. The remaining 426 observations are mapped in Fig. 11. Two observations from this dataset were removed from the subsequent numerical analysis of the insect's geographic distribution, since they appear to be outliers, and it could not be confirmed that a population has actually established at either of these locations. The observations discarded, shown as yellow dots in Fig. 11, are from Te Kaha, Bay of Plenty, in October 2021 (iNaturalist 96763859), with coordinates that are possibly inaccurate, and from Taupō in July 2022 (iNaturalist 178798045). The insect in the latter observation was found in a campervan and had possibly just traveled from a different location.

The maximum diameter of the species' geographic range in New Zealand has been increasing steadily since 2012 (Fig. 12A). A straight line with a slope of 36.96 km/year is a good fit for the observed data ($R^2 = 0.94$), indicating that the insect has been advancing at an average of 18.5 km per year in all directions.

The increase in land area occupied by the species' geographic range (Fig. 12B) is best approximated by a second order polynomial ($R^2 = 0.97$), with a coefficient of the quadratic term equal to 271.8 (km/year)^2. If the region occupied by the insect were circular, this would be equivalent to the insect advancing at an average $\sqrt{271.8 \div \pi} = 9.3$ km per year in all directions. The discrepancy between the two numbers calculated here is easily explained by

Fig. 9. *Pterapotrechus salomonoides* (Karny, 1929) terminalia. **A–D.** Adult ♂. Tamborine Mountain, QLD. MPN OR547. **A.** Dorsal. **B.** Ventral. **C.** Lateral. **D.** Posterior. **E, F.** Adult ♀. Auckland, New Zealand. MPN OR533. **E.** Ventral (subgenital plate). **F.** Ovipositor. **G.** Egg. Kerikeri, New Zealand. MPN OR540. Scale bars: 1 mm.

the constraints posed by New Zealand's geography, which does not lend itself to being approximated with a simple geometrical shape.

Population density in the city of Auckland, New Zealand.—In the city of Auckland, New Zealand, 352 *Pterapotrechus salomonoides* (Karny, 1929) observations were recorded on iNaturalist (https://www.inaturalist.org) by 243 individual observers from 1 July 2012 to 30 June 2024. Numbers broken down by year are graphed in Fig. 13.

The total number of *P. salomonoides* observations in Auckland increased from one per year in 2013 and 2014 to one hundred per year in 2024 (Fig. 13A). The total number of iNaturalist insect observations in Auckland also increased from 735 per year to 12,160 per year in the same time period. The percentage of *P. salomonoides* among all insect observations in Auckland increased six-fold from 0.14% in 2013 to 0.81% in 2024 (Fig. 13C).

Fig. 10. Live *Pterapotrechus salomonoides* (Karny, 1929) in its natural habitat. **A.** Adult ♂. Esme Lahey Environmental Park, Tamborine Mountain, QLD. **B.** Adult ♀. MacDonald Rainforest Circuit, Tamborine Mountain, QLD. **C.** Nymph with winged termite (*Schedorhinotermes* sp.) prey. MacDonald Rainforest Circuit, Tamborine Mountain, QLD. **D.** Mating pair. Mt Wellington, Auckland, New Zealand. Photo © Lilith Fisher. **E.** Nymphs in rolled leaves held together by silk strands. Tahuna Torea Reserve, Auckland, New Zealand.

The number of observers in Auckland who reported at least one *P. salomonoides* observation increased from one per year in 2013 to 85 per year in 2024 (Fig. 13B). The number of observers in Auckland who have reported at least one insect observation has also increased from 41 per year to 1,075 per year in the same time period. The percentage of *P. salomonoides* observers among all observers who have recorded at least one insect in Auckland has increased four-fold from 2.4% in 2013 to 9.2% in 2024 (Fig. 13D).

Dietary observations.—*Pterapotrechus salomonoides* specimens held in captivity were omnivores. They readily consumed grated apple and appeared to ignore grated carrot and pet food. They hunted and ate a variety of nocturnal invertebrates including moths, crane flies, and Orthoptera, but seemed unable to detect diurnal Diptera that rest at night.

A list of the food choices offered to the captive *Pterapotrechus salomonoides* specimens, and whether they were consumed or ignored, is shown in Table 2. Quantities eaten were not recorded.

Table 2. Results of dietary observations on captive specimens of *Pterapotrechus salomonoides* (Karny, 1929).

Food type offered	*Consumed*	*Ignored*
Noctuid moths (Noctuidae), various species	*	
Geometer moths (Geometridae), various species	*	
Crane flies (*Leptotarsus* sp.)	*	
Blowflies (*Calliphora* sp.)		*
Soldier flies (*Exaireta spinigera*)		*
Tree wētā (*Hemideina thoracica* nymph)	*	
Common garden katydid (*Caedicia simplex* adult)	*	
Rhaphidophorid (*Neonetus* sp.)	*	
Rhaphidophorid (*Pachyrhamma acanthocerum* nymph)		*
Conspecific (*Pterapotrechus salomonoides* nymph)	*	
Dead insects		*
Grated apple	*	
Grated carrot		*
Pet food		*

Discussion

Taxonomy.—The family Gryllacrididae Blanchard, 1845 is represented in Australia by 86 described species in 24 genera (Cigliano et al. 2024). With many taxa still undescribed, the true number of Australian species is probably much higher and may exceed 200 (Hale and Rentz 2001). Among the 86 named species, many were described based on a single specimen and remain poorly known today, so much so that even experts may be unable to identify them.

While the identity of the species that has established in New Zealand appears to be unambiguous, classification at genus level remains dubious. The type species of *Pterapotrechus* is *Paragryllacris beta* Griffini, 1909, now synonymized with *Pterapotrechus longicornis* (Tepper, 1892). The male of this species is still unknown. The shape of the female subgenital plate, ovipositor, and wings in *P. salomonoides* are so different that it is doubtful that the two species belong to the same genus at all. A modern description of *P. longicornis* and molecular data on other genera of Australian Gryllacrididae are needed before it can be determined what genus *P. salomonoides* (Karny, 1929) really belongs to.

Geographic distribution and habitat use in New Zealand.—*Pterapotrechus salomonoides* was first discovered in New Zealand in a house in Pukekohe, South Auckland (37.2°S, 174.9°E) in 1990. Further research indicated that a population had established locally (Green and Ramsay 2003). The first record outside of Auckland was from Whangapoua (36.7°S, 175.6°E) on the east coast of the Coromandel Peninsula in 1997 (Green and Ramsay 2003). Today, the species' geographic distribution has expanded as far north as Cable Bay, Northland (35.0°S, 173.5°E) and south to Raglan (37.8°S, 174.9°E) and Tauranga (37.7°S, 176.2°E).

Almost all observations are from inhabited areas or from marginal strips of native forest in the immediate vicinity of urban centers, i.e., from areas with constant human presence. There is no information on whether *P. salomonoides* is also occupying areas of less disturbed native vegetation.

Information about the geographic distribution and habitat use of *Pterapotrechus salomonoides* in its native range in Australia is lacking. Since the species is in a state of rapid expansion in New Zealand, we cannot draw any inference about its habitat use here, either. Absence from any given location does not necessarily imply that the habitat is not suitable; the insect may simply not have had time to establish yet. As a result of these considerations, we do not have the information required to estimate parameters for niche modeling to accurately predict the future expansion of the species' geographic distribution in New Zealand (Regos et al. 2019, Sillero and Barbosa 2021). *P. salomonoides* is not far from the northern end of the country. How far south its southern boundary is going to shift still is anyone's guess.

P. salomonoides is a heavily built, robust insect with shortened wings used for steering and stabilization while jumping rather than for proper flight. Even when threatened, it is more likely to stand its ground or jump than fly away (pers. obs.). Its range expansion pattern within New Zealand (Fig. 11) is also indicative of a short-distance flier.

P. salomonoides has not reached any of the numerous islands in the Auckland region except for Waiheke Island (36.7°S, 175.1°E) in the Hauraki Gulf. It is a very conspicuous insect that is likely to be noticed if it were present on Rangitoto Island or Tiritiri Matangi Island, both of which have a constant human presence. Rangitoto and Tiritiri Matangi are a mere 3 km from Auckland. Waiheke Island is almost twice as far, but it is connected to the mainland by up to 37 ferry sailings per day. It seems likely that the insect would have reached the island by traveling in a vehicle.

As to how *P. salomonoides* arrived in New Zealand, I consider it highly unlikely that it would have flown across the Tasman Sea. While winged insects (e.g., butterflies) occasionally reach our shores after being carried by westerly winds from Australia (Fox 1978), I do not believe it is possible for a poor flier like *P. salomonoides* to achieve such a feat. The raspy cricket would have most likely traveled as a stowaway in equipment shipped from Australia (Green and Ramsay 2003). Interceptions of Australian Gryllacrididae at the New Zealand border were reported in Green and Ramsay (2003).

Population density in New Zealand.—iNaturalist observations of *P. salomonoides* provide a useful resource, as this very conspicuous insect does not go unnoticed; it is present in high densities and is frequently encountered in inhabited areas. Most importantly, it is the only gryllacridid present in New Zealand, which makes misidentification nearly impossible. The same cannot be said about the Australian population. With 24 genera of Gryllacrididae present on the continent, the majority of Australian *Pterapotrechus* observations on iNaturalist are misidentified at genus level (pers. obs.).

The increase in *Pterapotrechus* observations in New Zealand over the past twelve years coincides with the increased popularity of the iNaturalist platform. For example, the number of citizens recording insect observations in Auckland has increased by a factor of 25 over the past twelve years: from 41 observers in 2013 to 1,075 observers in 2024. The total number of *Pterapotrechus* observations is therefore meaningless, unless it is compared to the total number of insect observations in the same geographical region and in the same time period.

The percentage of *Pterapotrechus* among all insect observations does not translate to an actual percentage in the insect population. *P. salomonoides* is a large, conspicuous insect that is easily spotted. Most insects are much smaller and are never recorded. The true fraction of *P. salomonoides* in the total insect population is smaller by several orders of magnitude. What matters is that the detectability of *P. salomonoides* can be reasonably assumed to remain constant. The percentage values graphed in Fig. 13C, D tell us that the population density of *P. salomonoides* in Auckland has increased at least five-fold over the past 12 years.

A limitation of the iNaturalist platform is that it makes it impractical to record the number of individual insects observed. Re-

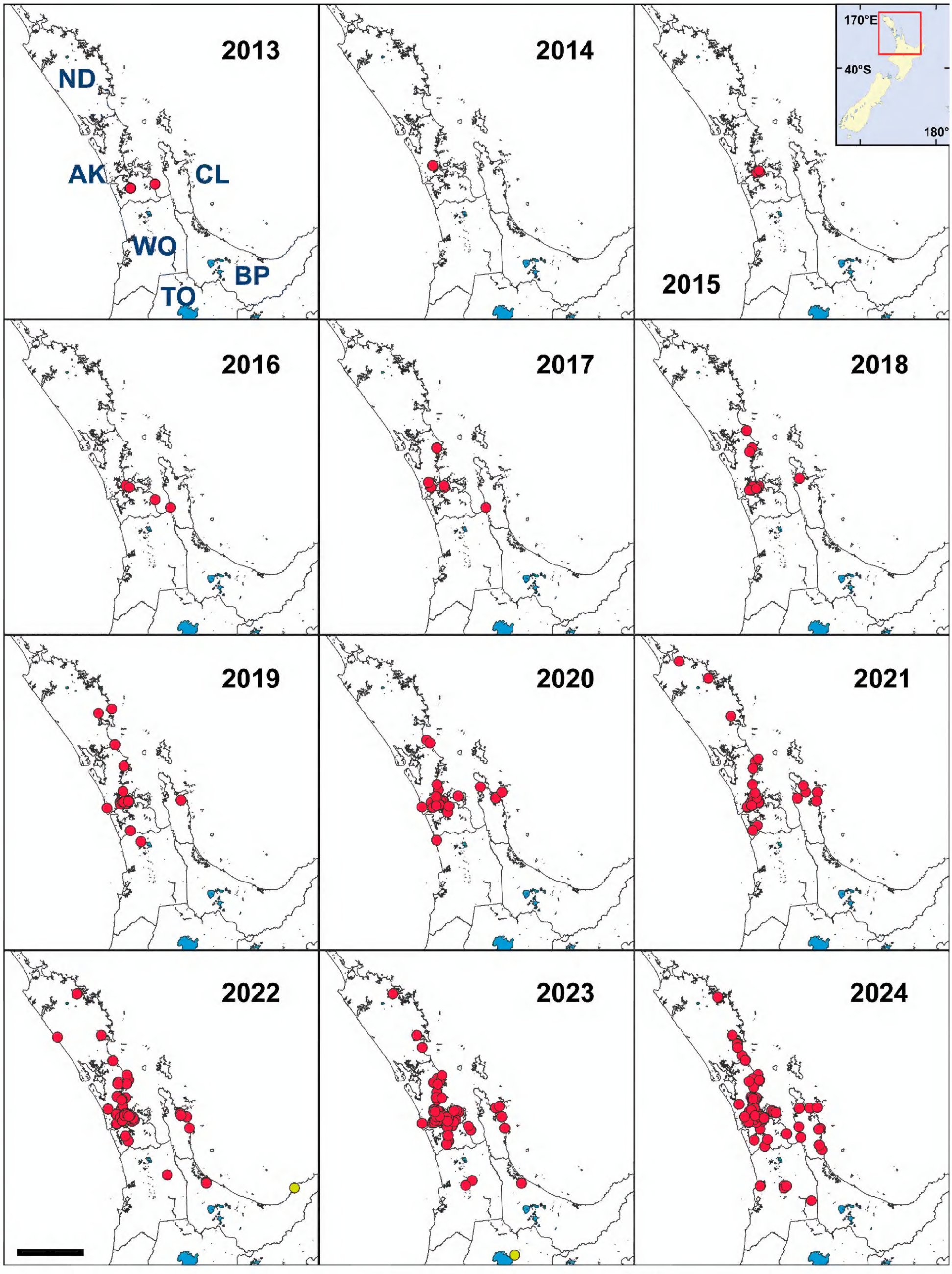


Fig. 11. Confirmed *Pterapotrechus salomonoides* (Karny, 1929) observations in New Zealand, from iNaturalist (https://www.inaturalist.org) and from other sources, 1 July 2012 to 30 June 2024. Yellow dots are considered outliers and were excluded from the numerical analysis. Scale bar: 100 km.

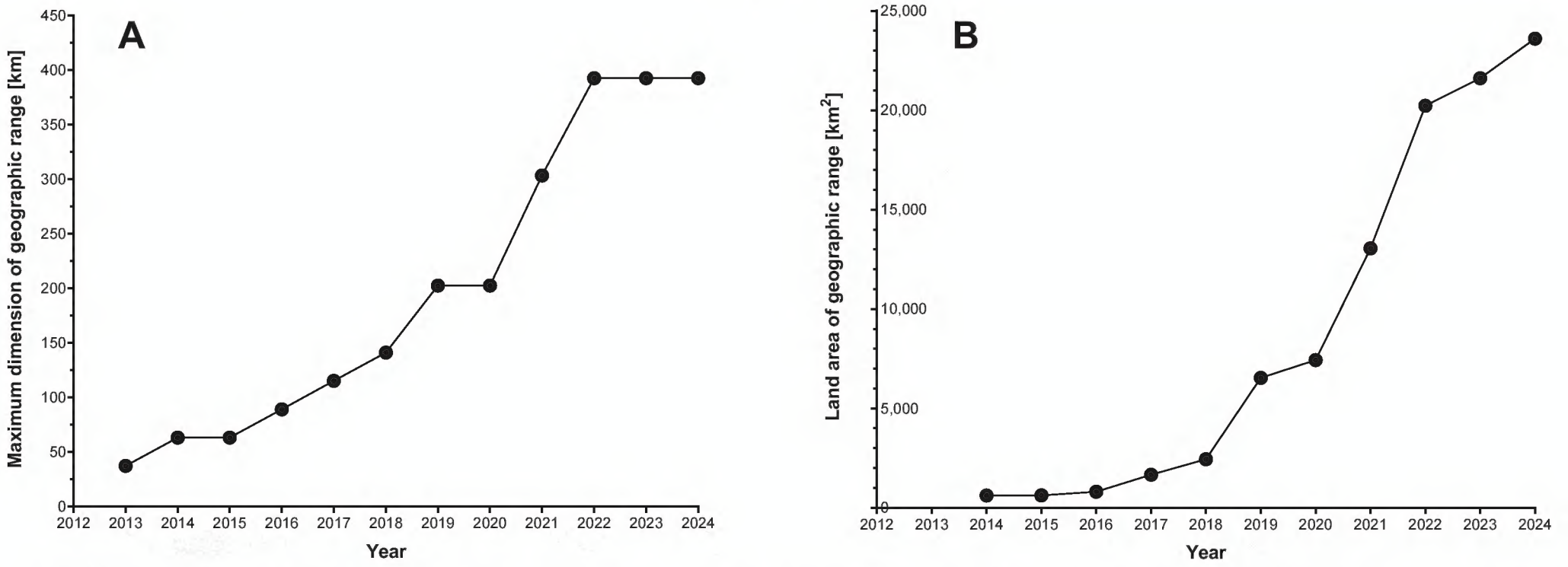


Fig. 12. Dimensions of *Pterapotrechus salomonoides* (Karny, 1929) geographic range in New Zealand, 2013 to 2024. **A.** Longest diagonal of polygon spanning all points (km). **B.** Land area under polygon spanning all points (km²). The polygon for a given year X's geographic range was generated by pooling all observations from 1 July 2012 to 30 June in the year X.

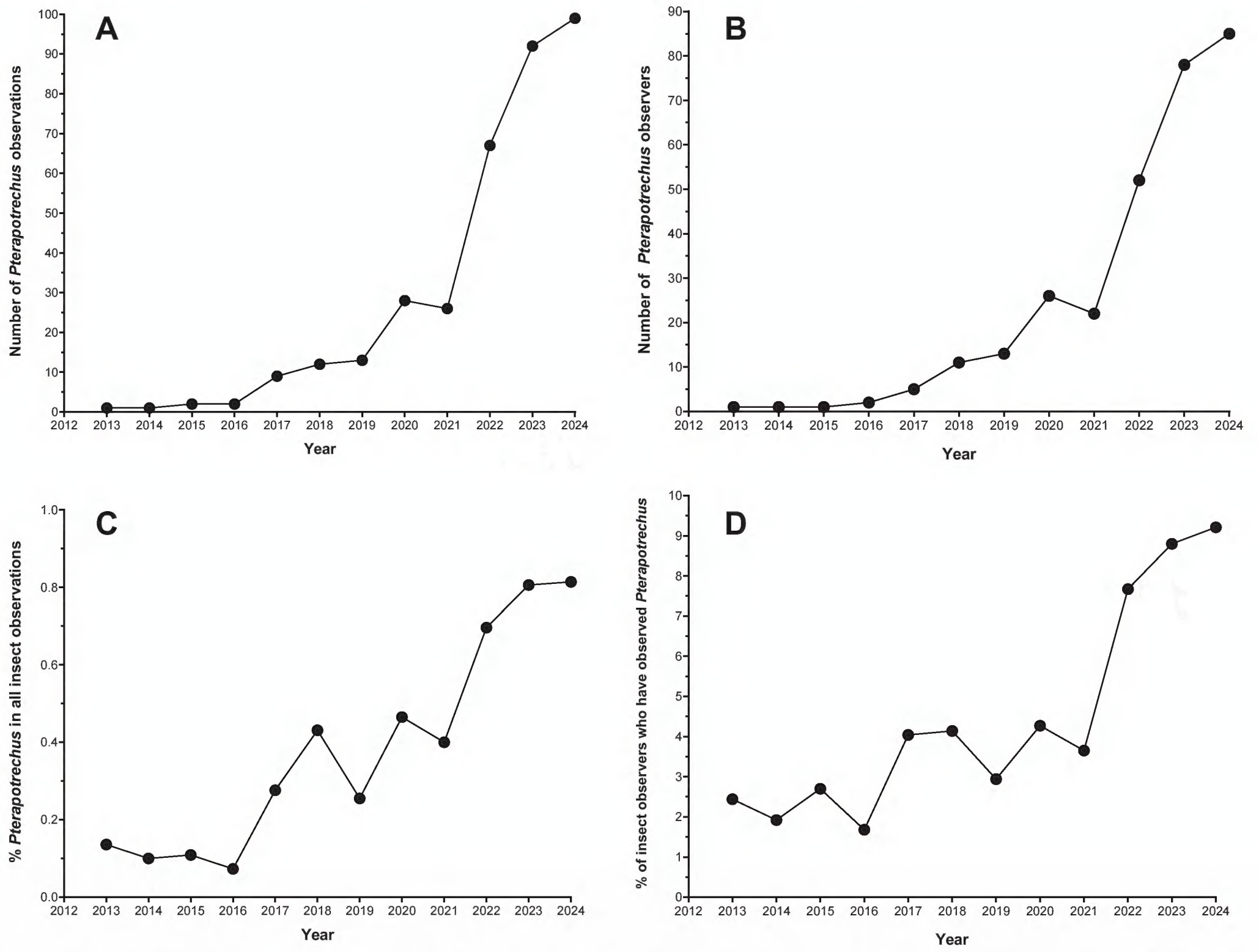


Fig. 13. Confirmed *Pterapotrechus salomonoides* (Karny, 1929) observations in the city of Auckland, New Zealand, from iNaturalist (https://www.inaturalist.org), 1 July 2012 to 30 June 2024. Observations in a given year X were recorded between 1 July in year X-1 and 30 June in year X. **A.** Total number of *Pterapotrechus* observations per year. **B.** Annual number of observers who have recorded one or more *Pterapotrechus* sightings. **C.** Percentage of annual *Pterapotrechus* observations among all insect observations recorded in Auckland in the same year. **D.** Percentage of annual insect observers who have recorded at least one *Pterapotrechus* sighting in the same year.

gardless of whether one insect or ten insects are seen, only one observation is recorded. Moreover, an observer's recording habits are likely to change as an insect becomes more common. An observer is more likely to report an insect they have not seen before but are unlikely to report it again if they start seeing it day after day. Based on these considerations, we may be underestimating the actual increase in *P. salomonoides* population density in New Zealand.

Despite these limitations, citizen observations recorded on iNaturalist allow us to track the range expansion and the build-up in numbers in the population of an invasive insect in a way that we could not before.

Dietary observations.—Green and Ramsay (2003) wrote that observations on *P. salomonoides* held in captivity "showed that the species is carnivorous, each specimen eating three to four small moth pupae per night as well as other foods such as fishmeal". They also reported episodes of cannibalism. Green and Ramsey, however, did not describe their setup for captive rearing, nor did they state what food choices the insects were offered.

My observations of specimens held in captivity confirm that invertebrates do indeed make up the majority of the diet of *P. salomonoides*, and that the crickets are active hunters rather than scavengers. Grated apple was also taken, indicating that *P. salomonoides* is not exclusively carnivorous. Pet food was not observed to be consumed but has been successfully used in the captive rearing of New Zealand rhaphidophorids and anostostomatids (Barrett 1991) and might be eaten by *P. salomonoides* if no other food were available.

In captivity, *P. salomonoides* hunts a variety of invertebrates, including Lepidoptera, other Orthoptera, and nocturnal Diptera (Tipulidae). Diurnal Diptera (Calliphoridae and Stratiomyidae), on the other hand, seem to be able to coexist with the predator without being eaten. One possible explanation for this is that the hunting of *P. salomonoides* may be triggered by the prey's movement. Since *P. salomonoides* is a nocturnal hunter, it primarily hunts other invertebrates that are also active at night. In the wild, I witnessed a winged termite (Genus *Schedorhinotermes* Silvestri, 1909) being preyed upon by a gryllacridid nymph (Fig. 10C). On a warm night, the winged termite was flying erratically in the beam of my torchlight, with fast and unpredictable movements. The gryllacridid nymph pounced on its prey with lightning-fast reflexes and struck with precision.

Cannibalism in Ensifera is no novelty, especially among crickets held in captivity in unnaturally crowded conditions (Boppré and Vane-Wright 2019) or in migratory katydids that attain very high population densities (Simpson et al. 2006). In 45 × 45 × 80 cm cages housing three *P. salomonoides* at a time, I witnessed cannibalism on one occasion when a male nymph in his final instar was eaten by an adult female, possibly while molting. Other insect prey were available in the cage.

Ecological impact on New Zealand ecosystems.—Anecdotal evidence suggests that the population density of *P. salomonoides* is higher in northern New Zealand than in its native range in Australia. My encounter rates in Auckland and Kerikeri, New Zealand, were significantly higher than in southern Queensland, Australia. iNaturalist observations of *P. salomonoides* are also much more numerous in New Zealand than in Australia. Given the insect's predatory habits, a legitimate question arises as to what impact the introduced raspy cricket might have on New Zealand's native invertebrate fauna.

At present, we do not have enough information to answer this question. Future studies should examine the diet of wild *P. salomonoides* using chemical and molecular analyses of the insect's gut contents. It also needs to be confirmed whether *P. salomonoides* is taking hold in intact native forest habitats. Repeated surveys should be conducted to monitor population trends of *P. salomonoides* and of selected target species to detect any correlations.

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Australian specimens were collected under Authority No. P-PTUKI-100481004 issued by the state of Queensland's Department of Environment and Science. As per the permit's conditions, an adult male *Pterapotrechus salomonoides* was donated to the Queensland Museum, where it can be accessed with catalogue number QM T260852. Export of the specimens to New Zealand was authorized under Permit PWS2024-AU-001334 issued by the Australian Government's Department of Climate Change, Energy, the Environment and Water.

References

Barrett P (1991) Keeping Wetas in Captivity. A Series of Nine Articles for Schools and Nature Lovers. Ramsay GW (Ed.). Wellington Zoological Gardens, New Zealand, 1–60. https://www.doc.govt.nz/globalassets/documents/science-and-technical/misc001.pdf

Benson DA, Cavanaugh M, Clark K, Karsch-Mizrachi I, Lipman DJ, Ostell J, Sayers EW (2013) GenBank. Nucleic Acids Research 41: 36–42. https://doi.org/10.1093/nar/gks1195

Béthoux O (2012) King crickets, raspy crickets & weta, their wings, their fossil relatives. Journal of Orthoptera Research 21: 179–225. https://doi.org/10.1665/034.021.0206

Béthoux O, Nel A (2001) Venation pattern of Orthoptera. Journal of Orthoptera Research 10: 195–198. https://doi.org/10.1665/1082-6467(2001)010[0195:VPOO]2.0.CO;2

Bin W, Bian X (2021) One new subspecies of the genus *Ultragryllacris* Gorochov & Dawwrueng, 2015 (Orthoptera: Gryllacrididae: Gryllacridinae) and its new record from China. Zootaxa 5047: 596–600. https://doi.org/10.11646/zootaxa.5047.5.10

Boppré M, Vane-Wright RI (2019) Welfare Dilemmas Created by Keeping Insects in Captivity. In: Carere C, Mather J (Eds) The Welfare of Invertebrate Animals. Animal Welfare, Vol 18. Springer, Cham, 23–67. https://doi.org/10.1007/978-3-030-13947-6_3

Brunner von Wattenwyl C (1888) Monographie der Stenopelmatiden und Gryllacriden. Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien 38: 247–394. https://www.zobodat.at/pdf/VZBG_38_0247-0394.pdf

Cadena-Castañeda OJ (2019) A proposal towards classification of the Raspy Crickets (Orthoptera: Stenopelmatoidea: Gryllacrididae) with zoogeographical comments: An initial contribution to the higher classification of the Gryllacridines. Zootaxa 4605: 1–100. https://doi.org/10.11646/zootaxa.4605.1.1

Casquet J, Thebaud C, Gillespie RG (2011) Chelex without boiling, a rapid and easy technique to obtain stable amplifiable DNA from small amounts of ethanol-stored spiders. Molecular Ecology Resources 12: 136–141. https://doi.org/10.1111/j.1755-0998.2011.03073.x

Cigliano MM, Braun H, Eades DC, Otte D (2024) Orthoptera Species File. http://orthoptera.speciesfile.org/ [Accessed 7 August 2024]

Crosby TK, Dugdale JS, Watt JC (1998) Area codes for recording specimen localities in the New Zealand subregion. New Zealand Journal of Zoology 25: 175–183. https://doi.org/10.1080/03014223.1998.9518148

Donald KM, Kennedy M, Spencer HG (2005) Cladogenesis as the Result of Long-Distance Rafting Events in South Pacific Topshells (Gastropoda, Trochidae). Evolution 59: 1701–1711. https://doi.org/10.1111/j.0014-3820.2005.tb01819.x

Folmer O, Black M, Hoeh W, Lutz RVR (1994) DNA primers for the amplification of mitochondrial cytochrome *c* oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 294–299. https://pubmed.ncbi.nlm.nih.gov/7881515/

Fox KJ (1978) The transoceanic migration of Lepidoptera to New Zealand – A history and a hypothesis on colonisation. New Zealand Entomologist 6: 368–380. https://doi.org/10.1080/00779962.1978.9722295

Green OR, Ramsay GW (2003) A winged wētā, *Pterapotrechus* (Orthoptera: Gryllacrididae), established in New Zealand. New Zealand Entomologist 26: 75–77. https://doi.org/10.1080/00779962.2003.9722111

Griffini A (1909) Studi sui Grillacridi del Museo di Oxford. Parte Ia, specie etiopiche, indo-malesi ed australiane. Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 47: 300–338. https://archive.org/details/attidellasocieti4708soci/page/n5/mode/2up

Hale RJ, Rentz DCF (2001) The Gryllacrididae: An overview of the world fauna with emphasis on Australian examples. In: Field LH (Ed.) The biology of wetas, king crickets and their allies. CABI Publishing, New York, USA, 95–110. https://doi.org/10.1079/9780851994086.0095

JASP Team (2023) JASP (Version 0.18.1) Statistics Computer Software. University of Amsterdam, The Netherlands. https://jasp-stats.org/ [Accessed 5 July 2024]

Karny HH (1928) Vorläufige Mitteilung über die wissenschaftlichen Ergebnisse meines Europa-Urlaubes (Schluß). Alphabetisches Verzeichnis. Entomologische Mitteilungen (Berlin-Dahlem) 17: 203–225. http://www.zobodat.at/pdf/Entomologische-Mitteilungen_17_1928_0203-0225.pdf

Karny HH (1929) Results of Dr. E. Mjöberg's Swedish scientific expeditions to Australia 1910–1913: 49. Gryllacrididae. Arkiv för Zoologi 20A: 1–86. https://doi.org/10.5962/bhl.part.20146

Karny HH (1937) Orthoptera Fam. Gryllacrididae. In: Wytsman P (Ed.) Genera Insectorum Vol. 206. V. Verteneuil & L. Desmet, Bruxelles, 1–317. https://www.biodiversitylibrary.org/item/223806#page/9/mode/1up

Kirby WF (1906) Orthoptera Saltatoria. Part I. (Achetidae et Phasgonuridae). In: A Synonymic Catalogue of Orthoptera (Orthoptera Saltatoria, Locustidae vel Acridiidae). British Museum of Natural History, London, Vol. 2, 1–562. http://www.biodiversitylibrary.org/item/29662

Larkin MA, Blackshields G, Brown NP, Chenna R, McGettigan PA, McWilliam H, Valentin F, Wallace IM, Wilm A, Lopez R, Thompson JD, Gibson TJ, Higgins DG (2007) Clustal W and Clustal X version 2.0. Bioinformatics 23: 2947–2948. https://doi.org/10.1093/bioinformatics/btm404

Lu XY, Luo H, Zhang Q, Bian X (2023) Comparative mitogenome analysis and phylogenetic inference of the genus *Ultragryllacris* (Orthoptera: Gryllacrididae). Zootaxa 5230: 439–455. https://doi.org/10.11646/zootaxa.5230.4.2

QGIS.org (2024) QGIS Geographic Information System. Open Source Geospatial Foundation Project. http://qgis.org [Accessed 27 July 2024]

Regos A, Gagne L, Alcaraz-Segura D, Honrado JP, Domínguez J (2019) Effects of species traits and environmental predictors on performance and transferability of ecological niche models. Scientific Reports 9: 1–14. https://doi.org/10.1038/s41598-019-40766-5

Rentz DCF, John B (1990) Studies in Australian Gryllacrididae: Taxonomy, Biology, Ecology and Cytology. Invertebrate Taxonomy 3: 1053–1210. https://doi.org/10.1071/IT9891053

Rentz DCF, Su YN, Béthoux O (2018) A new Raspy Cricket from the northern Australian Rainforests (Orthoptera: Gryllacrididae). Zootaxa 4514: 41–52. https://doi.org/10.11646/zootaxa.4514.1.3

Serville JGA (1831) Revue méthodique des insectes de l'ordre des Orthoptères. Annales des Sciences Naturelles 22: 138–139. http://www.biodiversitylibrary.org/item/29456

Sillero N, Barbosa AM (2021) Common mistakes in ecological niche models. International Journal of Geographical Information Science 35: 213–226. https://doi.org/10.1080/13658816.2020.1798968

Silvestri F (1909) Isoptera. In: Michaelsen W, Hartmeyer R (Eds) Die Fauna Südwest Australiens, Band 2. G. Fischer Verlag, Jena, 289–291. https://dn790009.ca.archive.org/0/items/diefaunasdwest02hamb/diefaunasdwest02hamb.pdf

Simpson SJ, Sword GA, Lorch PD, Couzin ID (2006) Cannibal crickets on a forced march for protein and salt. Proceedings of the National Academy of Sciences 103: 4152–4156. https://doi.org/10.1073/pnas.0508915103

Tamura K, Nei M (1993) Estimation of the number of nucleotide substitutions in the control region of mitochondrial DNA in humans and chimpanzees. Molecular Biology and Evolution 10: 512–526. https://doi.org/10.1093/oxfordjournals.molbev.a040023

Tamura K, Stecher G, Kumar S (2021) MEGA 11: Molecular Evolutionary Genetics Analysis Version 11. Molecular Biology and Evolution 38: 3022–3027. https://doi.org/10.1093/molbev/msab120

Tepper JGO (1892) The Gryllacrididae and Stenopelmatidae of Australia and Polynesia. Transactions of the Royal Society of South Australia 15: 137–178. http://www.biodiversitylibrary.org/item/54689#page/145/mode/1up

Thompson JD, Gibson TJ, Plewniak F, Jeanmougin F, Higgins DG (1997) The ClustalX windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. Nucleic Acids Research 25: 4876–4882. https://doi.org/10.1093/nar/25.24.4876

Trewick, SA, Hegg D, Morgan-Richards M, Murray T, Watts C, Johns P, Michel P (2022) Conservation status of Orthoptera (wētā, crickets and grasshoppers) in Aotearoa New Zealand, 2022. Department of Conservation, Wellington, NZ, 28 pp. https://www.doc.govt.nz/globalassets/documents/science-and-technical/nztcs39entire.pdf

Walker F (1869) Catalogue of the Specimens of Dermaptera Saltatoria in the Collection of the British Museum, London 2: 352. http://www.archive.org/details/catalogueofspeci02britrich

White A (1846) Insects of New Zealand. In: The zoology of the voyage of H.M.S. Erebus and Terror, under the command of Captain Sir James Clark Ross, R.N., F.R.S., during the years 1839 to 1843. Vol.4(2). London, Green and Longman, 1–24. https://www.biodiversitylibrary.org/page/6963015#page/206/mode/1up

Wiedemann CRW (1830) Aussereuropäische Zweiflügelige Insekten: 618–619. https://www.biodiversitylibrary.org/item/88495#page/636/mode/1up

Supplementary material 1

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Data type: pdf
Explanation note: Contains the translation of the original description of *Pterapotrechus salomonoides* from the German language; also tables of material examined in a more readable format.
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